

Radio 1

Radio

Radio 2

Introductory Question

- If you took an electrically charged ball and shook it up and down rapidly, charges in a nearby metal object would move in response. How far away could that metal object be and still respond?
 - A. 1 meter
 - B. 1 kilometer
 - C. The other side of the universe

Radio 3

Observations about Radio

- It can transmit sound long distances wirelessly
- It involve antennas
- It apparently involves electricity and magnetism
- Its reception depends on antenna positioning
- Its reception weakens with distance
- There are two styles of radio: AM and FM

Radio 4

3 Questions about Radio

- How can a radio wave exist?
- How is a radio wave emitted and received?
- How can a radio wave represent sound?

Radio 5

Question 1

- How can a radio wave exist?
 - What is an electromagnetic wave anyway?
 - How can an electric field exist without charge?
 - How can a magnetic field exist without pole?

Radio 6

Electromagnetic Waves

- Radio waves are a class of electromagnetic waves
- Electromagnetic waves
 - are structures in space that consist only of electric fields and magnetic fields.
 - They are emitted or received by charge or pole,
 - but are self-sustaining while traveling in vacuum
 - because their electric and magnetic fields endlessly recreate one another.

Radio 7

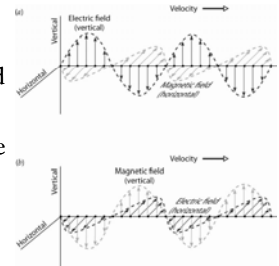
Electromagnetism (Version 3)

- Magnetic fields are produced by
 - magnetic poles (but free poles don't seem to exist),
 - moving electric charges,
 - and changing electric fields.
- Electric fields are produced by
 - electric charges,
 - moving magnetic poles,
 - and changing magnetic fields.

Radio 8

Structure of a Radio Wave

- Electric field is perpendicular to magnetic field
- Changing electric field creates magnetic field
- Changing magnetic field creates electric field
- Polarization of the wave is associated with the wave's electric field



Radio 9

Clicker Questions

- If you place a positive test charge in a radio wave while there are no other charges nearby, will that test charge experience a force?

- A. Yes
- B. No

Radio 10

Question 2

- How is a radio wave emitted and received?

Radio 11

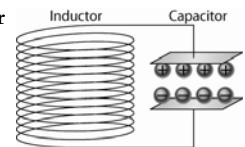
Launching a Radio Wave

- Accelerating charge emits electromagnetic waves
- The more charge and the more it accelerates, the stronger the resulting electromagnetic wave
- Radio stations need to emit strong waves
 - so they move large amounts of charge
 - with the help of resonant devices: tank circuits

Radio 12

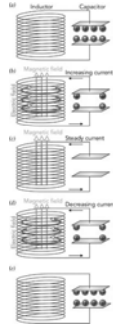
A Tank Circuit

- A tank circuit
 - is a harmonic oscillator for charge
 - its charge flows rhythmically through the inductor, from one capacitor plate to the other and back again.
- Its energy alternates between
 - magnetic field in its inductor
 - electric field in its capacitor



Tank Circuit Oscillation

- The frequency of the tank circuit is determined only by its inductance and its capacitance.
- It can store a great deal of energy and have an enormous amount of charge moving through it.
- Tank circuits come in many shapes, including straight lines!

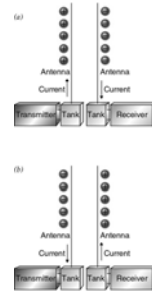


Tank Circuits in Radio

- Tanks build up energy at a specific frequency
- Two tanks help radios *emit* radio waves
 - The first tank circuit feeds the antenna
 - The second tank circuit IS the antenna
- Two similar tanks help radios *detect* radio waves

Emitting Radio Waves (Part 1)

- A transmitter uses a tank circuit to “slosh” charge up and down its antenna, which acts as a second tank.
- A receiver uses a tank circuit to detect charge “sloshing” on its tank-circuit antenna.
- Transmitter antenna charge affects receiver antenna charge
- Antenna orientations matter!



Emitting Radio Waves (Part 2)

- Accelerating charge emits radio waves
 - Stationary charge produces an electric field
 - Steady current produces a magnetic field
 - Changing current produces a changing magnetic field, produces a changing electric field, prod...
- A radio wave consists only of an electric and magnetic field
- A radio wave travels through empty space at the speed of light

Clicker Question

- Does a flashlight emit radio waves?
- No
 - Yes, whenever it is on.
 - Yes, but only as you turn it on or off.

Introductory Question (revisited)

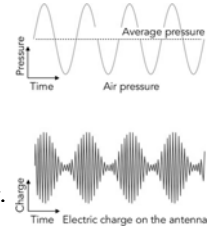
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Question 3

- How can a radio wave represent sound?

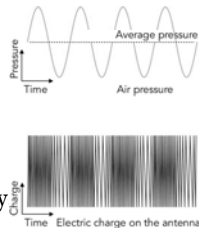
AM Modulation

- Information can be encoded as a fluctuating amplitude of the radio wave
- The air pressure variations that are sound cause changes in the amount of charge moving on the antenna and thus the intensity of the wave
- The receiver detects these changes in radio wave intensity.



FM Modulation

- Information can be encoded as a fluctuating frequency of the radio wave
- The air pressure variations that are sound cause slight shifts in the frequency of charge motion on the antenna and the frequency of the wave
- The receiver detects these changes in radio wave frequency



Summary about Radio

- Radio waves are emitted by charge accelerating on a transmitting antenna
- Radio waves are detected when they cause charge to accelerate on a receiving antenna
- Radio waves consist only of self-sustaining electric and magnetic fields
- Radio waves can represent sound information as variations in amplitude or frequency